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Soilutions

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Manure – A Resource Management Challenge

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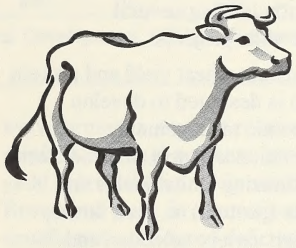
There are significant world market opportunities in livestock based products. Alberta livestock producers are well situated to meet these market demands by expanding their cattle and hog operations. One of the potential barriers to growth is effective management of manure. Some in the agricultural community and most of society at large view manure as a waste management problem. However, approaching manure as a resource management challenge provides an opportunity to capture additional value out of the crop-livestock interface. Manure is a valuable resource that if managed properly would:

- Allow us to recycle most of the nutrients taken up annually in feed grains and harvested forages.
- Significantly reduce the per unit cost of production on manure land.
- Improve soil by increasing the inherent productivity and reducing erosion risk.
- Act as a feedstock for other processes, such as biogeneration of energy or production of unicellular protein, before land application.
- Maintain market access by enhancing Alberta's reputation as an environmentally conscious production region.

Instead of shipping micro and macronutrients offshore as grain, increased use of crops for animal feed will create an opportunity to close the nutrient cycle and return nutrients to Alberta soils. Additional benefits



accrue from the non-nutrient effects of manure on land productivity. These include increased soil organic matter, increased water-holding capacity and improved tilth.

Manure produced by Alberta's livestock herd this year contains sufficient nitrogen to supply the needs of 6 million acres of barley. If the cattle herd doubled and the swine herd quadrupled there would be sufficient manure nitrogen to grow approximately 13 million acres of barley. If the calculation is based on phosphorus, there is currently sufficient phosphorus in manure to meet the annual needs of over 10 million acres of barley. Increasing livestock numbers and food processing will mean a proportional increase in manure. Recycling nutrients from manure must be an essential component in developing integrated and sustainable agricultural production in Alberta.

Additionally, there are many possibilities for recapturing value from waste materials before land application. On a dry weight basis, a kilogram of manure contains approximately 80 percent of the nutrient and energy value as a kilogram of the original feed material. Using some portion of the unused nutrients and energy in the manure before land application, should create a value chain from manure and turn a waste management cost into revenue. Possibilities include recycling through unicellular protein for livestock feed, generation of methane and composting of manure with products such as rock phosphate to reduce bulk and to increase nutrient content. Numerous other processes could potentially be used to capture additional value and reduce the amount of material returned to the land while increasing its nutrient content.

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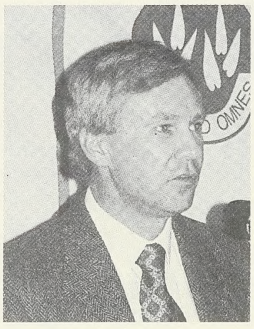
Alberta
AGRICULTURE, FOOD AND RURAL DEVELOPMENT

Dr. Ross McKenzie Honored



Dr. Ross McKenzie received the Alberta Institute of Agrologists - Distinguished Agrologist Award. This award is presented to members of the institute who have provided outstanding service to the agricultural industry. Ross is well recognized for his expertise in soil fertility, especially, phosphorus and agronomic crop production practices in both irrigation and dryland conditions. His interest and dedication in ensuring the farming community receive the best possible soil test recommendations has been instrumental in the direction of his work. Ross is and has been the team leader on numerous and varied province-wide projects, coordinating industry, university, laboratory, provincial and federal personnel. Ross is currently leading several province-wide projects:

1. Optimizing wheat yield and protein which is designed to develop agronomic management information that will aid producers in optimizing wheat yields and quality (protein) on their farms, through variety selection and fertilizer management.
2. Maximizing barley production by varietal selection and nutrient management, which is designed to aid barley producers in production decisions.
3. Improved nutrient management strategies for peas which is designed to aid growers in optimizing their fertilizer and inoculant inputs to achieve best pea yield and quality.

Ross has a number of other ongoing projects including the Soil and Crop Diagnostic Field School at Lethbridge, Barley Silage Production in Alberta, Winter Wheat Production, Dry Bean Production and Manure and Nutrient Management. Ross was pleased to receive this award. He was, however, unsure if it was the Distinguished or Extinguished Agrologist Award, referring to the 22 years he has worked in Alberta Agriculture; first as a Soil Specialist, then as an Irrigation Specialist and finally for the past 16 years, as a Research Scientist specializing in soil fertility. Congratulations Ross!

Manure – A Resource Management Challenge (cont'd)

There are significant gaps in our knowledge of how to create and manage sustainable manure based cropping systems under the soil and climate conditions in Alberta. In particular, information is lacking in the wetter Black and Grey soil zones of the province and on cropping systems based on hog manure. Information exists on crop response in the year of manure application, but there is very little information on how crops respond in systems where manure has been applied annually for a number of years or applied periodically such as every three or four years. Another knowledge deficit is lack of nutrient release curves in soils that have been manured repeatedly over time. Without a better estimate of nutrient release, it is difficult to develop meaningful management tools such as improved soil tests or crop response models.

Better management of waste stream nutrients in cropping systems will require improved understanding and technical innovation on issues such as nutrient cycling in pasture systems, methods of controlling cycling time and breakdown rates on crop land and application of manure on forage stands.

We need to increase our scientific understanding of soil-crop systems in which livestock manure is a major input. Increased knowledge on how these cropping systems behave will allow the agricultural industry to develop practical manure based cropping systems that take advantage of manure as a valuable source of nutrients. It will also allow us to place a value on the use of manure as a soil amendment that can improve overall productivity of our land base. It will contribute to the management of manure in ways that ensure that negative impacts on soil and water are minimized. These three factors must be integrated in order to determine the economic value of manure. Our contention is that the economic value of manure is potentially much higher than currently realized. This undervaluing is the primary reason why manure is viewed by some as a potentially environmentally damaging waste rather than a valuable resource or commodity.

Sulphur and Canola Production - Elemental Concepts

Elston Solberg - Research Agronomist, Soil Fertility

Table 1. Nutrients removed by equivalent yields of canola, wheat and alfalfa in Alberta.

Crop	Yield	Crop Part	Nutrients Removed (lb/ac) N	P	K	S
Canola	35 bu/ac	seed/straw	105	22	69	21
Wheat	50 bu/ac	seed/straw	106	17	67	13
Alfalfa	5 tons/ac	total	290	32	250	30

Adapted from Alberta Agriculture Food & Rural Development, SCDC Laboratory Yield Increase tables.

Sulphur (S) is an essential plant nutrient for all crop production. For canola producers this is especially true since canola has a higher requirement for S than other annual crops. In fact, canola requires about the same amount of S as phosphorus (P) (Table 1). Unfortunately, many producers are losing 10 to 40% of their potential canola yield because they are unaware of the importance of S in canola yield and are unable to recognize mild to moderate S deficiency symptoms in their canola crops. In addition, if S levels are low enough to significantly reduce canola yield then they are low enough to reduce the yield and quality of other crops in the rotation.

In Alberta, 7,000,000 acres are considered S deficient for optimum canola production and the acreage is increasing. Plants use S in the sulphate (SO_4-S) form, which, like nitrate (NO_3-N), is very mobile and leachable. Soil organic matter is a primary source of plant available SO_4-S. Soils that are sandy, low in organic matter and found in upper to mid-slope positions are especially prone to sulphur deficiency since the small amount of SO_4-S released from organic matter is susceptible to leaching loss. Soils most prone to S deficiency are the Grey Wooded, Thin Black and Black soils because they were formed in areas of relatively high rainfall (leaching) and have greater yield potential (high S demand). Brown and Dark Brown soils are usually not considered deficient in S because they often have gypsum ($CaSO_4$) laden subsoils. However, within all soil zones, various combinations of high rainfall, high yield potential, low organic matter, topography and coarse texture predispose fields to S deficiency.

In the Prairie Provinces, the most commonly used sulphur (S) fertilizers contain soluble sulphate (SO_4-S) rather than elemental sulphur (S^o). Products containing ammonium sulphate (21-0-0-24, 20-0-0-24 and 19-3-0-22) predominate while products comprised of elemental S [0-0-0-90 (Tiger 90) and 0-0-0-95 (SulFer 95)] are only recently finding increased market acceptance.

Sulphate fertilizers are effective in rapidly overcoming crop sulphur deficiencies, as they are immediately available for crop uptake. In fact, canola growers can frequently correct an observed S deficiency with an application of SO_4-S based fertilizer (and a prayer to the rain gods) as late as bolting and still capture most of the crop's yield potential. The greatest risk associated with the immediate availability of SO_4-S fertilizers is the tendency for leaching below the crop-rooting zone especially in sandy areas subjected to heavy rainfall.

For fertilizer manufacturers and producers, elemental sulphur has the advantages of ready supply, lower production costs, and because of its high analysis, lower transportation cost and fewer drill fills during field operations (Table 2). However, elemental sulphur (S^o) requires biological oxidation (conversion) to plant available sulphate (SO_4-S) before crops can use it. In the short-term, this imparts a delayed availability of the S^o fertilizer for a rapidly growing crop.

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Table 2. Relative amounts of 20-0-0-24 and 0-0-0-90 required to supply the desired amount of sulphur.

Desired Rate of S (lb/ac)	Amount of Fertilizer Required to Supply Desired Amount of Sulphur (to closest lb/ac) Sulphur Source Utilized: Ammonium Sulphate (20 - 0 - 0 - 24)	Elemental Sulphur (0 - 0 - 0 - 90)
10	42	11
20	84	22
30	125	33
40	167	44

Sulphur and Canola Production (cont'd)

The factors affecting S^o conversion have been studied throughout the world for the past 70 years but only recently in Western Canada. In fact, S^o has long been used as an effective S source in many parts of the world.

For researchers, agronomists and especially producers it is important to consider how S^o and SO_4-S fertilizers differ and how these differences fit and compliment one another in a given crop production system. How these products fit into a given producers production system will vary depending on their crop rotation, equipment, soil type, severity of S deficiency, yield goal and fertility program philosophy.

For producers in western Canada, the primary factors that influence the conversion rate of S^o to SO_4-S are particle size and method of S^o application. Commonly used S^o fertilizers are made up of granules that are comprised of thousands of S^o particles. These particles provide surface area on which the soil organisms "feed" and convert the S^o to SO_4-S. The smaller the particle, the larger the surface area, the more rapid the conversion to SO_4-S. Research in Alberta has shown that fertilizer materials with S^o particles < 150 microns (μm) will oxidize rapidly under Prairie conditions **provided** they are well dispersed throughout the soil. Consequently, for short-term availability, research has shown that the most effective method of applying S^o is surface broadcast without immediate (or no) incorporation. This allows the S^o granules, comprised of 1000's of small particles, to lie on the soil surface where they are dispersed by rainfall and freeze/thaw cycles. This provides maximum contact between S^o and the soil thereby allowing rapid conversion of S^o to SO_4-S. Banding or seed placement of S^o fertilizer places large numbers of small S^o particles in close proximity to one another. The granules become encapsulated by soil, which reduces the exposed S^o surface area and vastly reduces conversion rate to SO_4-S.

Among S^o fertilizers, sources there are other differences to consider. SulFer 95 (S95) is comprised totally of elemental S particles < 74 μm (Table 3); so with good dispersion relatively rapid conversion of S95 to SO_4-S could be expected. Tiger 90 (T90) is comprised of 90% S^o and 10% bentonite clay. Bentonite clay swells when wetted and acts to fracture the S^o into 1000's of relatively small particles. These particles have a wide range of sizes (Table 3). Assuming good particle dispersion, particles < 150 μm will convert quickly to SO_4-S with conversion slowing as particle size increases. Because of its larger average granule mass, T90 provides fewer "crop feeding sites" for equivalent fertilizer rates (Table 3). Therefore, because of larger granule mass and wider particle size distribution, dispersion is critical for short-term conversion of T90 to SO_4-S. One rainfall is usually sufficient to disperse S95 while several are required to disperse T90. Because of their much higher S analysis, both T90 and S95 provide far fewer feeding sites when compared to 20-0-0-24 (Table 3).

Consequently, on severely deficient soils, crop response to S^o based fertilizers is generally inferior to SO_4-S based fertilizers in the initial year of application. In subsequent years, applications of S^o tend to produce responses similar to SO_4-S applications. Dr. Toogood and his University of Alberta colleagues noted in 1962 that, "The average long-term leguminous hay yields (1940-61) from plots fertilized every 2nd year with flowers of S^o was equal to or greater than plots receiving SO_4-S every 2nd year. In addition, this benefit carried over to the cereal crop that followed hay in the rotation". It is important to note that by today's standards, S^o flowers are an inferior product **and** because the S was applied to the forage component of the rotation, it

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Table 3. Comparison of fertilizer S^o particle size distribution, granule weight and feeding sites.

S Fertilizer	S Analysis (%)	Typical S^o Particle Sizes Ranges	Granule weight (mg)	Approximate Averages No. of Granules/ft^2 (crop feeding sites) for 10 lb S/ac
20-0-0-24	24	not applicable	14	31.0
Tiger 90	90	18% > 2000 μm 37% 600-2000 μm 23% 150-600 μm **25% < 150 μm1**	36	3.2
SulFer 95	95	**100% < 74 μm2**	15	7.3

[1] Particle size distribution after 2 simulated wet/freeze cycles and 1 rain (Solberg et al., 1986)
[2] From manufacturers specifications. S95 is fully dispersed after only 1 rain (Solberg et al., 1996).

Sulphur and Canola Production (cont'd)

Table 4. Forage yield response to various S fertilizers at Mayerthorpe (1993-95).

Fertilizer Treatment[1]	Forage Dry Matter Yield (kg/ha) 1993	1994	1995
Nil	2330 a[2]	2650 a	2030 a
N Only	4490 b	4640 b	4330 b
N & Ammonium Sulphate	5720 c	6700 c	6020 c
N & SulFer 95	5310 c	6360 c	5580 c
N & Tiger 90	4570 b	5840 c	6050 c

[1] N applied at 120 lb N/acre as 34-0-0 and S at 15 lb S/acre in May of each year.
[2] Yields followed by the same letter are not significantly different using LSD.

was surface broadcast. In other words, even this inferior product worked well when it was applied in the optimal, most dispersed manner.

Current forage research (Table 4) using modern S^o products on a severely S deficient site (< 10 lbs S/ac in the 0 - 24" depth) support these ancient findings. In the 1st year, only T90 did not perform as well as the other S fertilizer sources. The combination of greater granule mass (less feeding sites), larger average S^o particle size and more difficult dispersion provides a likely explanation. The much smaller S^o particle size of the easily dispersed S95 converts rapidly to SO_4-S. By the 2nd study year, all S fertilizers gave statistically similar yields and this continued through year 3. We also know from previous research that a 2nd (and subsequent) application of S^o fertilizer converts more quickly than the initial application. A larger microbial population that continues to feed on residual S^o is the likely explanation. For this study, it is important to remember all fertilizers were surface broadcast and left exposed on the soil surface.

Limited amounts of field research have looked at surface application of S^o and annual crop production. Some initial work (Table 5) showed potential in the concept of surface application of S^o after canola seeding. Unfortunately, this work was terminated after only a single research season due to lack of funding.

The N only treatment reduced canola yield by 9 bu/acre. Canola yield reduction frequently occurs when N is applied, without S, to a very S deficient soil. This is likely the most significant loss impacting canola producers in S deficient areas because they are not only losing yield but also the cost of the N input that is causing the yield loss.

Surface application after seeding (SAS) improved canola yields by 3 bushels/acre for both S95 and T90. With SAS application of S95, yields were similar to 20-0-0-24 indicating an increase in the rate of S95 conversion and crop availability. SAS application of T90 improved canola yield but yields for both T90 treatments were less than the check indicating that S^o conversion was not rapid enough. If SAS application of S95 can improve polish canola yields on severely S deficient land then application the previous fall or early in the spring should be even better. More research is required in this area.

Elemental Sulphur Fertilizer Management Strategies

Producers who have adopted an annual application maintenance approach to S in their fertility program will have the most success with S^o fertilizer. Producers who only apply S in the canola year of their rotation will likely be disappointed with S^o fertilizer use. Producers that wish to convert to an S^o program from an SO_4-S program have to seriously consider how they are going to manage around the initial slow conversion (hump) year. Strategies include:

1) Applying 1.5 to 2 times as much S^o, as compared to SO_4-S, in the 1st or 2nd year of conversion.
2) Applying a physical blend of S^o and SO_4-S fertilizers. Tiger 60 and 70 are examples.
3) Applying the S^o in the fall previous or as early in the spring as possible.
4) Surface applying the S^o fertilizer whenever possible.

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Table 5. Effect of sulphur source and method of application on polish canola yield (2 site years).

Fertilizer	S Rate (lb S/ac)	Application Method	Yield (bu/ac)
No S and No N	0	None	34
N only[1]	0	None	25
20-0-0-24 plus N	30	Band	39
S95 plus N	30	Band	35
S95 plus N	30	Surface After Seeding (SAS)	38
T90 plus N	30	Band	29
T90 plus N	30	Surface After Seeding (SAS)	32

[1] N applied as a band at 120 lb N/ac.

Sulphur and Canola Production (cont'd)

Table 6. Effect of seed placed sulphur sources and soil moisture on canola emergence (5% SBU[1]).

Rate of seed placed S (lb S/ac)	Canola Emergence (%) - 15 days after seeding			
	Dry Soil - 40% F. C.[2]		Wet Soil - 70% F. C.	
	20-0-0-24	S95	20-0-0-24	S95
10	28	74	82	100
20	13	69	48	94
40	5	54	18	91

[1] SBU = Seed Bed Utilization
[2] F.C. = Field Capacity

5) For producers located in areas prone to S deficiency, adopting a program of applying S° every year since responses are likely in all of their crops.

Do elemental S fertilizers offer any other potential benefits that have not been discussed?

Agronomists and researchers have suggested the following:

- Less crop injury when S° is seed placed as compared to 20-0-0-24. This has been recently confirmed (Table 6) but keep in mind that seed placement of S° does not give rapid initial conversion to SO_4-S. Annual use of blends (S° plus SO_4-S) initially and S° alone in subsequent years may satisfy most S deficient situations.
- Root maggot inhibition or control. Current research (Dr. Lloyd Dosdall, Alberta Research Council, Vegreville) is investigating whether S° has a role in reducing root maggot infestation. Results to date are somewhat inconclusive.
- Reduced seeding rates of canola by blending with canola sized granules of S° fertilizer. European producers have successfully blended a canola-sized version of Tiger 90, called Onset, to reduce seeding rates by half but retaining even stands. Reduced seed cost is the primary motive with additional potential benefits of increased S availability and possible root maggot inhibition.
- Impregnation of S° granular fertilizer with pre-emergent herbicides for surface application in direct seeding systems. This would optimize the short-term conversion of S° and potentially be a good carrier for various pre-emergent herbicides. A canola sized S° granule would give more crop feeding sites and better herbicide coverage.

Conclusion

I have been in fields and research trials where S° and SO_4-S fertilizer sources have performed very well. Having said that, I have been in fields and research trials where S° and SO_4-S fertilizers have not performed at all! How can that be?

At the risk of over generalizing, in "failed" SO_4-S canola fields the 2 main culprits are leaching loss and/or too low a rate applied for the yield goal or severity of S deficiency. In 'failed' S° canola fields the main culprits are generally combinations of inappropriate method of application (banding or seed placement), too low a rate for the severity of S deficiency and S application only in the canola year. For both S° and SO_4-S, the most dramatic failures are often seen in crops following forage in the rotation. Usually the forage has not been fertilized at all and is devoid of nutrients for subsequent annual crops. The first 2 years after forage can be dynamite for S deficiency problems especially in the Grey soil zones.

To me all of these observations point to a general lack of understanding of S nutrition and the different management required for S° and SO_4-S fertilizers. For producers, agronomists and researchers it is necessary to become more knowledgeable about S nutrition in general and the nuances of S° and SO_4-S fertilizer management in particular.

When managed correctly elemental sulphur fertilizers provide another option for producers striving to optimize their overall production. The choice to effectively use S° fertilizer as part of a fertility program requires a deeper understanding of crop nutrition and soil management. This "new" knowledge will hopefully spill over to other aspects of crop and soil fertility management.

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"Manure Happens" - So make the most of it!

Dr. Ross McKenzie - Research Scientist, Soil Fertility

Livestock manure is receiving increasing public attention since the general public regards ground and surface water quality degradation from agricultural sources as one of the major environmental problems of the 1990's. Excessive applications of manure, applied repeatedly over a period of years, will eventually result in nutrient overloading in soil. Nutrient overloading, poor handling or poor timing of manure applications could lead to contamination of ground and surface water with nutrients and possibly pathogenic microorganisms. Odours from heavily manured fields reduce air quality. Manure also contains variable amounts of soluble salts and trace elements. A combination of these factors can lead to environmental problems where manure is mismanaged.

However, if proper manure management practices are followed, animal wastes can be utilized as a valuable nutrient resource rather than treated as a waste. Manure is an excellent "organic" fertilizer containing nitrogen (N), phosphorus (P), potassium (K) and many other essential nutrients. Manure can physically benefit the soil. It adds organic matter to the soil, which improves soil tilth and structure. Because manure is "organic", there is a perception that manure cannot be harmful to soils or the environment. There is no question that adding modest amounts of manure to soil is very beneficial. However, too much of a good thing over a period of time could lead to problems.

To prevent problems from developing, intensive livestock operators must use best manure management practices (BMP). It is very important to remember that BMP will vary from farm to farm, depending on: the climatic zone of the farm, the type and number of animals in confinement, the total amount of manure produced and how the manure is handled, stored and applied. It will also depend on the amount of land available to apply manure, soil types on the farm, types of crops grown and crop yield potential. BMPs need to be tailored to match the needs of each farm. Producers must take a pro-active approach to manure management to ensure the sustainability of both their farm and the environment. Following a step by step approach is essential in planning best manure management practices for each farm.

Amount of manure produced

The place to start is to determine how much manure is produced by the livestock operation. The Alberta Agriculture booklet titled "Code of Practice" (available from district offices) provides general estimates of manure produced. However, amounts produced vary considerably depending on methods of storage and handling. The most accurate way is to weigh every truckload of manure that leaves the operation. Alternately, use an average truck weight and then count the number of truckloads of manure removed.

Manure storage

The next factor is ensuring a suitable on-farm location to store manure. In the case of solid manure, storage is needed for up to six months, while waiting for appropriate times to apply the manure onto fields. The storage site must be on soil with very low permeability to prevent contaminants from seeping into the subsoil and eventually the ground water. It is very important to ensure leachate from the manure piles cannot leave the storage area in surface runoff during periods of heavy rain or rapid snowmelt. In the case of liquid manure storage, seepage from the containment area must be prevented. Line containment areas using flexible membranes or other approved types of impermeable material. In all cases, divert surface water runoff away from manure storage areas to prevent contamination of surface water.

Determine where and how much manure can be applied.

The factors of "where to apply the manure" and "what rates to apply" require the greatest attention. These two factors go hand-in-hand and involve: identifying the fields where manure can be applied, determining the acreage of each field and soil testing each field.

Soil sample each field to a depth of at least 2 feet (90 cm) and take depth samples at 0-6, 6-12 and 12-24 inches. Have samples analyzed at each depth for nitrate-nitrogen, phosphorus, potassium, sulphate-sulphur, pH and electrical conductivity. The top two depths should also be analyzed for boron, copper, iron, manganese and zinc. Take twenty random sampling sites across each field to make up a composite soil sample for each depth. Each field should be analyzed each year, either in late fall or early spring.

This information is needed to identify which nutrients are deficient in each field to determine how much of each nutrient must be added to the soil to ensure adequate levels for crop growth.

Ideally, soil sampling to a depth of 4 feet (1.2 metres) is recommended every few years to ensure that a nutrient leaching problem is not developing. If a leaching problem is recognized, it can be dealt with before it becomes a serious concern.

Representative manure samples should be taken each year and analyzed

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Manure Happens (cont'd)

for **total and available nutrients**, specifically nitrogen, phosphorus and potassium. **Available nutrient** refers to an element in the soil that can be readily absorbed by growing plants. **Total nutrient** refers to an element in the soil in both plant available and unavailable forms. When determining manure application rates, available nutrients and the portion of the unavailable nutrients that will be released from manure in the year of application must be matched to crop nutrient requirements in each field. Book values of typical nutrient levels can be obtained from the Code of Practice. Remember that nutrient content of manure is highly variable, depending on source, feed and method of storage.

It is impossible to apply manure to meet exact crop requirements for all nutrients. When manure is applied based on one nutrient, other nutrients either will be over or under applied. To complicate the situation, nutrients such as nitrogen and phosphorus are contained in a number of different available and unavailable compounds. The unavailable compounds break down and release nutrients at different rates over a period of years. The problem is that the nutrient content of manure does not match the nutrient requirements of most crops. For example, if feedlot manure is applied to meet the nitrogen requirements of wheat or barley, phosphorus will be applied at approximately three to four times the rate of crop removal. Repeated applications over a period of years will result in build up of high soil phosphorus levels.

Most producers have applied manure based on nitrogen content, leading to a build up to soil P. Some fields now exceed 400 lb/ac of available P in the top six inches of soil. This is equivalent to 1770 lb/ac of 12-51-0 phosphate fertilizer. To further complicate things, the soil test does not measure the unavailable forms of P in the soil. Producers in this situation will have to take serious steps to draw down soil phosphorus levels and avoid manure or phosphate fertilizer application for a period of years. Practices will have to change to draw down the P levels. For example, applying manure annually to five years of barley silage to meet N requirements may have to be followed by four years of alfalfa to draw down the P soil levels. Another alternative is to apply manure to meet P crop requirements and supplement with nitrogen fertilizer. There is no single best answer.

Therefore, when developing a long-term manure management plan, producers have to decide whether to apply manure based on N or P. In the long term, it is advisable to use phosphorus as the nutrient to match with crop removal rather than nitrogen.

For existing operations, this may mean expansion of their land base or working with adjacent farms to apply manure. In addition, commercial nitrogen fertilizer may have to be added to make up the difference between what the crop requires and what is contained in the manure.

All the information that has been gathered has to be put together to develop the manure management plan. Alberta Agriculture has developed a set of calculation sheets to work through this process. In Worksheet 1, the total amount of manure produced on the farm in one year is determined. Then in Worksheet 2, the total nutrient content of the manure produced is calculated. Worksheets 3 and 5 calculate the rates of manure applica- tion to each crop in each field based on nitrogen and phosphorus require- ments, respectively. When there is not sufficient land base on the farm to apply all the manure produced, then Worksheets 4 and 6 determine how much additional land is needed. These worksheets are an excellent exercise to work through to develop an understanding of how much manure can be applied to different crops and fields based on crop removal rates for each soil zone. Although it seems like a daunting exercise, it is essential in planning your manure use program and optimizing crop production.

In situations where intensive livestock producers do not have a large enough land base to spread manure, there is an opportunity to work with their neighbours. Commercial fertilizer prices have dramatically increased over the past several years. One alternative is for neighbours nearby a feedlot or other type of intensive livestock operation to use manure to offset the rising cost of commercial fertilizers.

Determine when and how to best apply the manure.

The decision of when to apply manure is relatively easy. Obviously, manure cannot be spread during the growing season when annual crops are actively growing. Manure application onto perennial crops is not normally recommended due to a higher possibility of runoff. The only exception is if liquid manure can be shanked directly into the soil. Spreading manure onto frozen soils is not recommended due to the possibility of runoff problems from rapid snow melt which can carry dissolved and solid manure particulate into surface waters, causing contamination. When solid or liquid manure is applied, incorporate it into the soil the same day as it is applied. Incorporation is critical to reduce nitrogen losses to the air and prevent air quality concerns. The longer manure is left on the soil surface, the greater the nitrogen losses which reduces the value of the manure as a nitrogen fertilizer (Table 1). Also, the longer the manure is left on the soil surface, the greater the potential

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Manure Happens (cont'd)

Table 1. Approximate dry matter and fertilizer nutrient composition of various animal manures.

Method of Application	Type of Waste	Nitrogen Loss (%)*
Broadcast without cultivation	solid	21
	liquid	27
Broadcast with cultivation	solid	5
	liquid	5
Knifing	liquid	5
Irrigation	liquid	30

* Percent of total N in waste applied which was lost within 4 days after application

Source: Sutton et al., Purdue Univ. 1D-101.

environmental concerns. Immediate incorporation of manure prevents potential runoff. Apply manure in early spring or after harvest and before freeze-up in the fall.

The BMP for liquid manure is to shank it directly into soil. This has the advantages of eliminating nitrogen losses and avoiding air quality concerns. In very special cases, liquid manure could potentially be applied through an irrigation sprinkler system at very low application rates, however, extreme care to prevent surface water runoff and nitrogen losses to the air are required. Therefore, it is not normally a recommended practice.

Value of manure

It is difficult to put an exact value on the nutrient value of a manure application because of the variability in nutrient content and the nutrients that are released over a period of years. Other benefits such as better soil tilth and less horsepower required to work the soil are hard to quantify. However, if we assume that commercial nitrogen (N), phosphate (P_2O_5) and potassium (K_20) fertilizers have values of $0.35, 0.30 and 0.20 per pound respectively and feedlot manure has an N (total), P_2O_5 and K_2O content of 21, 18 and 26 lb respectively in each ton of manure, then the approximate value of one ton of feedlot manure has a value of $18.00. If manure was applied at 10 tons per acre, the value of nutrients applied in the manure would be $180.00/ac. The total amounts N, P_2O_5 and K_20 added would be 210, 180 and 260 lb/ac. Keep in mind however, that in the case of feedlot manure, only about half of the N and P will be available in the year of application. A 10 ton/ac application rate should provide enough nutrients in the first year of application to meet the nutrient requirements of an 80 bu/ac barley crop. If 10 tons of manure is applied each year the decay rate of nutrients released from the manure must be taken into account. Table 2 gives an example of the decay rate of nitrogen over an eight-year period.

The cost of delivery and spreading of manure is between $3.00 and $5.00/ton depending on the hauling distance. At a 10 ton/ac application rate, the total cost per acre of the manure could be $30.00 to $50.00. This is excellent value considering that about $180/ac of nutrients is added to the soil.

Producers within 5 to 8 miles of a confined livestock operation should consider using manure as a fertilizer source. The potential to purchase manure by paying for delivery and spreading has a double benefit. The confinement operator can dispose of extra manure and a nearby neighbour has the advantage of an excellent source of fertilizer for the cost of transportation. In addition, manure applied to machine levelled or eroded fields will also improve the physical

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Table 2. Example of nitrogen release (decay rate) from an annual 10 ton per acre application of feedlot manure with a total N content of 200 lb/ac, over 8 years.

Year:	1	2	3	4	5	6	7	8
Total Manure N (lb/ac):	200	200	200	200	200	200	200	200
Year 1 N:	100	50	25	12	6	3	2	1
Year 2 N:		100	50	25	12	6	3	2
Year 3 N:			100	50	25	12	6	3
Year 4 N:				100	50	25	12	6
Year 5 N:					100	50	25	12
Year 6 N:						100	50	25
Year 7 N:							100	50
Year 8 N:								100
Cumulative N Available (lb/ac):	*100*	*150*	*175*	*187*	*193*	*196*	*198*	*199*

Manure Happens (cont'd)

quality of the soil. When neighbouring farmers can take advantage of win-win situations like this, the whole agricultural community benefits!

Hopefully these tips on developing a sound manure management plan are useful. If you have questions when working through the planning process, contact a Crop Specialist at an Alberta Agriculture District Office near you for assistance. Remember, "Manure Happens" so make the most of it!

Ox-eye Daisy

Dan Cole - Research Agronomist, Weeds

Ox-eye daisy (*Chrysanthemum leucanthemum*) is a perennial weed of increasing concern in pastures and haylands of western and east-central areas of Alberta. Once established, ox-eye daisy can quickly displace preferred forage in pastures and haylands. Cattle avoid grazing ox-eye daisy and consequently it produces dense stands that severely reduce the carrying capacity of pastures. If eaten by dairy cattle the weed gives the milk a disagreeable taste. The protein level of ox-eye daisy, at the time of first cut, is only 6% which is equivalent to that of straw.

This non-native plant is difficult and costly to control. In research trials conducted in 1987/88 near Edson and Buck Lake, only Tordon 22K applied at a rate costing $55.00/acre provided good ox-eye daisy control, but also selectively removed the legumes from the stand.

A research project was initiated in 1994 to develop a practical, cost-effective means of controlling ox-eye daisy for higher yields of better quality forage and longer maintained stands. It is a collaborative affair with partners from the Agronomy Unit - Dan Cole, Jerome Lickacz, technical staff, University of Alberta - Dr. Jane King, Crop Specialists - Fred Young and Harvey Yoder, Agricultural Fieldmen - Gordon Walker, Greg Ibach, Dave Watson, Jeff Warawa and Eldon Kozak, Industry - Agrium and Westco and of course, the cooperating producers.

Some of the preliminary observations rising from this study:

- Two years of spring surface applied fertilizer to soil test recommendations at $59.00/ac/year effectively removed ox- eye daisy from fenced-off pasture (Figure 1).
- Surface application of 100 kg N/ha, 45 kg P_2O_5/ha, 44 kg K_2O/ha and 15 kg S/ha doubled even tripled total forage production in the fenced off pasture.
- Alfalfa was the most competitive of the eight forage species seeded into an ox-eye daisy infested pasture that was broken up and reseeded. Forage species in order of decreasing competitiveness were: alfalfa, alsike clover, meadow brome, timothy, smooth brome, orchard grass, creeping red fescue, and kentucky bluegrass.
- Escort at 12 g/ac at $19.00/ac provided excellent control of ox-eye daisy in the first year when applied in May to ox-eye daisy under 10 cm in height. However, this herbicide also removed the legume growth reducing competition. Spring applied nitrogen fertilizer increased grass growth and consequently competition, reducing ox-eye daisy numbers into the year following herbicide application. Other herbicides being evaluated are 2,4-D amine, 2,4-D ester, Estaprop, Banvel + 2,4-D ester, Refine Extra, Lontrel, Garlon, DyVel DS and MCPA amine.

Research will be carried through until 1998 to determine the longevity of the effects of both the herbicides and the fertilizers. Future research is needed to determine minimum rates of fertilizer needed to suppress ox-eye daisy and optimum application timing.

Practical implications:

- Surface applied fertilizers can cause forage to out-compete ox-eye daisy in an established forage stand and assist a herbicide in providing longer-term control of this weed. This is in addition to increased forage production.
- Data is being collected to add ox-eye daisy to the Escort label through the Minor Use registration program. Escort can then be recommended for control along with proper fertility management.
- Early spring application of Escort herbicide, along with fertilizer application to soil test recommendations may be an effective recommendation for the control of ox-eye daisy in grass only pasture and hay stands. For mixed forage stands, the use of fertilizer alone for at least two springs may be an effective recommendation. Proper forage stand management and not overgrazing pasture are essential for managing weeds. Producers will benefit economically and will have fewer weed problems when fertilizer is applied on pasture and haylands.

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Ox-eye Daisy (cont'd)

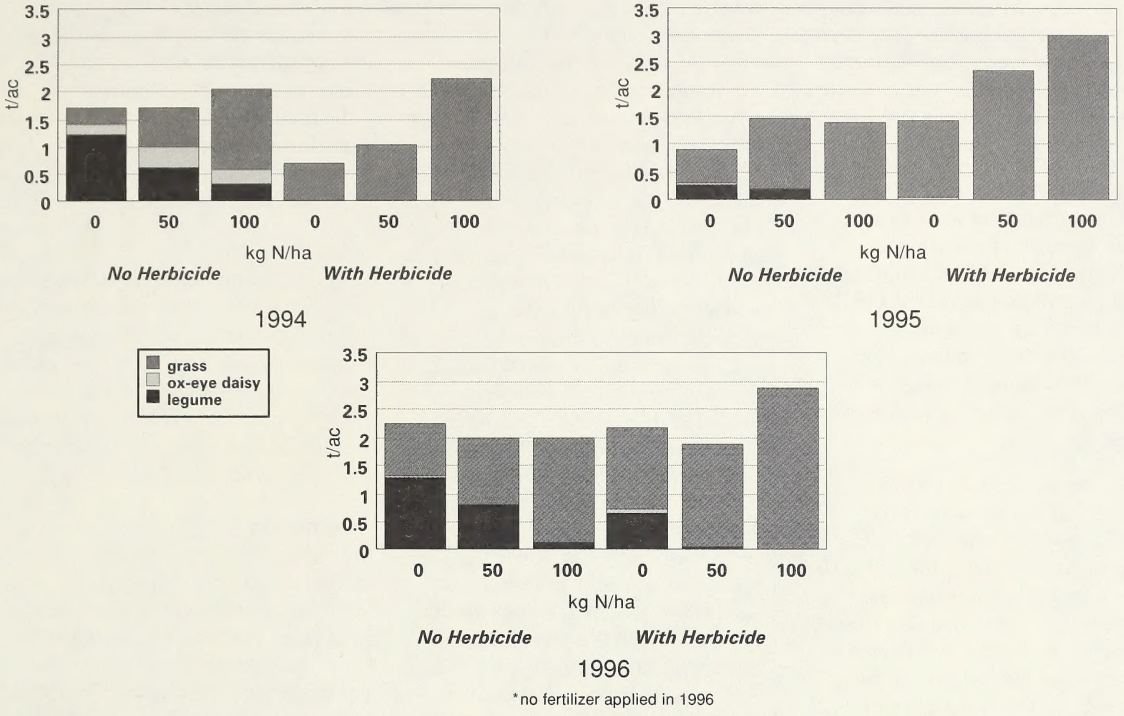

Figure 1. Effect of herbicide and fertilizer on ox-eye daisy, grass and legume content of hayland.

Growing Winter Wheat in Alberta

Dr. Ross McKenzie - Research Scientist, Soil Fertility

Winter wheat is an excellent crop for many southern Alberta farmers. Production potential is also very good for many areas in central Alberta. Winter wheat can potentially yield 20% higher than spring wheat, making it an economically attractive crop. As well, because it is seeded in the fall and harvested earlier than spring wheat, it spreads out the workload and results in better time management for farmers.

Growing winter wheat is fairly straight forward. However, management practices are quite different than for other crops. Therefore, to grow winter wheat successfully a number of specific management practices must be followed.

Variety Selection

In southern Alberta, AC Readymade is the newest and probably the best bet for most farmers to grow. In central Alberta, CDC Kestrel is the best variety due to its winter hardiness. Four other new varieties have been licensed recently; however, seed is still in the multiplication stages and is not yet available to farmers.

Seeding

Ideally, winter wheat should be direct seeded into standing stubble. Seeding into canola or pea stubble offers crop rotation advantages such as reduced weed problems, the volunteer is easy to control and reduced insect and disease problems. Standing stubble will help trap snow, which acts as an insulator. Four inches of snow will normally provide sufficient insulation to ensure overwinter survival.

Best results are obtained by seeding in the first two weeks of September. This allows sufficient time for plants to germinate, develop at least three leaves and develop a crown (base of the shoot where secondary roots develop). Later seeding may result in

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Growing Winter Wheat in Alberta (cont'd)

poorly established plants and reduced winter survival. If the late seeded crop survive the winter, it may still suffer from delayed heading, later maturity, increased weed problems and lower yield potential.

The ideal seeding rate for winter wheat is higher than what most growers use for spring wheat. Generally, winter wheat should be seeded at a minimum rate of 120 lb/ac. Although winter wheat has considerable ability to tiller, best yields are obtained with higher seeding rates and row spacings of 7 to 9 inches.

Winter wheat has a very short coleoptile. The coleoptile is the extension of the seed embryo that pushes its way through the soil to the surface from which the first leaf develops. It is very important to seed winter wheat 0.5 to 1 inch deep. Winter wheat seeded deeper than 1 inch will result in reduced emergence. Deeper seeding also delays emergence causing weaker, spindly plants that are more susceptible to winter kill.

Frequently, soil moisture is low in stubble fields in early September. Farmers are faced with the decision as to whether to seed into dry soil or wait for rain. Saskatchewan research has shown that winter wheat will germinate at very low soil moisture levels. There is a high probability of success from seeding winter wheat in the first two weeks of September rather than waiting for rain. Soil temperature can dramatically affect the time it takes winter wheat to germinate. For example, winter wheat will take only 6 days to emerge at a soil temperature of 20°C, while it takes 12 and 30 days to emerge at soil temperatures of 10 and 5°C respectively.

Winter wheat should only be seeded into "clean fields". Volunteer cereals can harbor a microscopic wormlike mite called the leaf curl mite, which can transmit the wheat streak mosaic virus. Any actively growing green vegetation such as volunteer cereals or grasses can serve as a host for the mites. Mites can move short distances via air currents from the infected host plants into the emerging winter wheat spreading the virus. In the spring, mites from the infected winter wheat can move to the emerging spring wheat and the cycle continues. Damage can range from small infected patches to complete crop failure. The only way to control this disease is to break the disease cycle by ensuring that there is no volunteer grain in the field to host the leaf curl mite.

Fertilization

Alberta research has shown that phosphate placed with or near the seed at the time of seeding improves plant growth in the fall resulting in better winter hardiness. Approximately 20 to 25 lb/ac of phosphate is usually adequate. Previous recommendations suggested that nitrogen fertilizer should only be spring applied, because fall applied nitrogen may reduce winter hardiness. Research results from southern Alberta over the past four years has clearly shown that fall applied nitrogen fertilizer has not reduced over winter hardiness. It also showed that nitrogen fertilizer banded before seeding at times dried out the seedbed and resulted in a rougher and lumpier seedbed which had an effect on germination and emergence. Seed-placed nitrogen fertilizer using urea through a narrow opener at rates greater than 50 lb N/ac (10% SBU-spreading the seed and fertilizer over 0.75 inches with a row spacing of 8 inches) had a detrimental effect on winter wheat germination and emergence. It is recommended that fields be soil sampled and tested for macro and micronutrients to determine optimum nitrogen fertilizer requirements. If time does not permit soil testing or if fall soil moisture conditions are very dry, it is best to apply approximately 50 to 75% of estimated nitrogen requirements at the time of seeding, soil test in late fall and broadcast additional required nitrogen in early spring depending on soil moisture conditions.

Weed control

Weed pressure in winter wheat crops is usually lower than with other crops because of winter wheat's competitive nature and the head start it gets in the spring. Winter annuals are the greatest problem. However, these can easily be controlled with inexpensive products such as 2,4-D or MCPA.

Summary

Winter wheat can be an easy and profitable crop to include in a rotation. Following simple, straightforward management practices; seed early, seed shallow, increase seeding rate, provide adequate nutrition, control winter annuals will greatly increase the probability of success.

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